DESIGN OF COUNTERFORT RETAINING WALL WITH INTEGRATION OF RICE HUSK ASH ALONG MAIN ROAD OF NORZAGARAY HOMES PHASE 2, BRGY. BITUNGOL, NORZAGARAY, BULACAN

A Research Proposal

Presented to the Faculty of Civil Engineering Division

La Concepcion College

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science in Civil Engineering

Major in Construction Engineering

and Management

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RECOMMENDATION

This is to certify that this research entitled "DESIGN OF COUNTERFORT RETAINING WALL WITH INTEGRATION OF RICE HUSK ALONG MAIN ROAD OF NORZAGARAY HOMES PHASE 2, BRGY. BITUNGOL, NORZAGARAY, BULACAN," prepared and submitted by Kyle Abijah R. Baguan, Hazel Mae S. Borra, Diana Mea B. Padel, & Romulo B. Ramirez have been examined and PASSED the Pre-Oral Defense.

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CERTIFICATE OF ORIGINALITY

This certificate demonstrates the fact that the work was original to the researchers and that no other individual or group has written or published it before. Additionally, it declares that until proper acknowledgement has been given to them, no honors or recognition from other universities, colleges or higher education institutions were claimed here.

On top of that, we claim that our study's intellectual content is the product of our hard work, which required using both simple terminology and efficient presentation methods in addition to the group's original ideas.

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CHAPTER 1

The Problem and Its Background

Introduction

The Philippines has been prone to various natural hazards, due to its demographics that it is located at the pacific ring of fire and typhoon belt, making the occurrence of landslides inevitable (Hilotin, 2022). Counterfort retaining wall as proposed landslide protection offers a compelling engineering-based solution that supports the successful prevention of landslides. Installing retaining walls in landslide-prone areas is a promising approach for improving safety.

This research will consider the production of sustainable retaining walls. Rice husk ash will be added as a partial cement substitute. The 10-20% of total cement volume will be considered and replaced by RHA, since it is the optimal percentage for the RHA to provide highest compressive strength in concrete, with an improved initial surface absorption and greater eco-strength efficiencies. (Hasan et al. 2022).

This study specifically focuses on the counterfort retaining wall along main road of Norzagaray Homes Phase 2, Barangay Bitungol, Norzagaray, Bulacan. By designing the retaining wall, this research facilitates the use of software such as STAAD pro for efficient design. STAAD pro will calculate external stability (Overturning, Sliding, & Soil Bearing Capacity) & internal stability (Moment, Shear, Reinforcement analysis) based on the soil profile of hillside in Norzagaray Homes

Phase 2. Additionally, excel sheets will be used to calculate conceptual estimates for the design project based on the design data.

The design developed will then be compared based on cost analysis of design with different variation of materials; the local RHA, & plain cement concrete. This comparison will determine which design is more cost-effective, ensuring optimal use of funds without compromising code provisions. This study highlights the importance of retaining walls in preventing landslides, improving soil stability for hillside.

Background of the Study

Norzagaray Homes Phase 2, Barangay Bitungol, Norzagaray, Bulacan have been affected by extensive heavy rainfall in recent years, excessive heavy rainfall which causes landslides along the main road of Norzagaray Homes. Due to occasional landslides the fallen debris causes a partial road blockage which results traffic congestion in transportation. It also poses a significant threat to the safety and security of surrounding homes.

With the continuous rain, the Barangay Bitungol officials promptly responded by temporary road blockage and conducting road cleanup. Barangay Bitungol has reached out to higher authorities for a discussion to explore the options for excavating and leveling the hillside. The authorities are currently seeking to identify the developer to collaborate on finding a solution to ensure the safety of pedestrians and commuters.

The design of retaining walls is crucial in areas prone to soil erosion and landslides. A retaining wall is a structured design that holds back soil preventing erosion and creating level areas on sloping. It can protect the infrastructure and roads during landslides in Norzagaray Homes Phase 2, Barangay Bitungol, Norzagaray, Bulacan.

Through this study, the researchers aim to help the Barangay homeowners and officials to have additional information on decision making in solving the soil stability issue. In this study, counterfort retaining wall were proposed, and determined which is more cost-effective based on cost-analysis with different variation in materials to be

implemented. This research can be used as a reference guide for further improvement of landslide protection of the community safeguarding the motorists and nearby homes in Norzagaray Homes.

Theoretical Framework

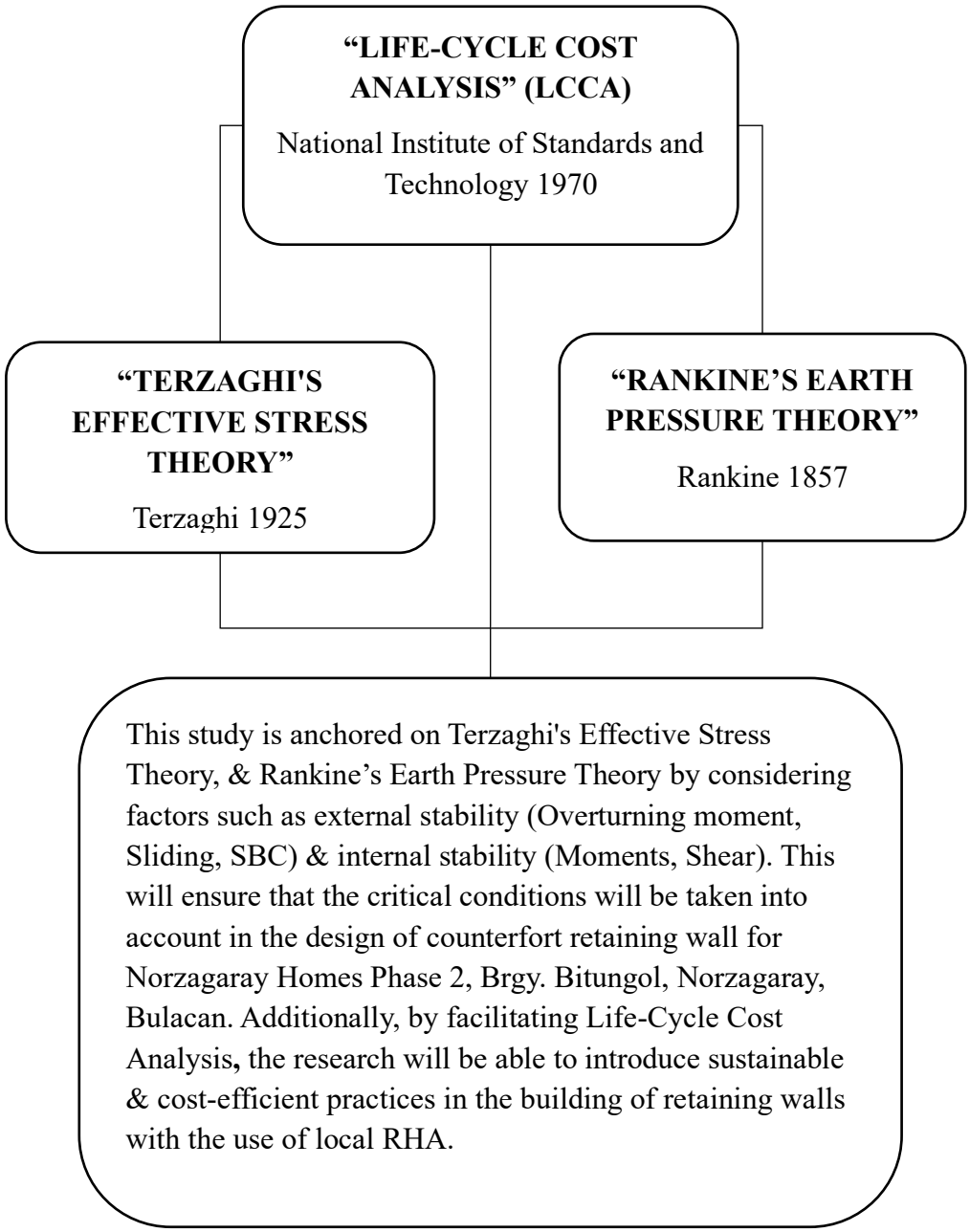
"LIFE-CYCLE COST ANALYSIS" (LCCA)
National Institute of Standards and Technology 1970
"TERZAGHI'S EFFECTIVE STRESS THEORY"
Terzaghi 1925
"RANKINE'S EARTH PRESSURE THEORY"
Rankine 1857
This study is anchored on Terzaghi's Effective Stress Theory, & Rankine's Earth Pressure Theory by considering factors such as external stability (Overturning moment, Sliding, SBC) & internal stability (Moments, Shear). This will ensure that the critical conditions will be taken into account in the design of counterfort retaining wall for Norzagaray Homes Phase 2, Brgy. Bitungol, Norzagaray, Bulacan. Additionally, by facilitating Life-Cycle Cost Analysis, the research will be able to introduce sustainable & cost-efficient practices in the building of retaining walls with the use of local RHA.

Figure 1. *Theoretical Framework*

Conceptual Framework

INPUT	PROCESS	OUTPUT
1. What is the demographic profile of the respondents in terms of: 1.1. Age 1.2. Length of Residency 2. How does the frequent landslide affect the citizens of Norzagaray Homes Phase 2, Brgy. Bitungol, Norzagaray, Bulacan in terms of: 2.1. Transportation 2.2. Perceive Safety 3. How does the counterfort retaining wall under various loading combinations perform structurally in terms of 3.1. Stability against Overturning 3.2. Stability against Sliding 3.3. Stability against Bearing Capacity Failure 4. How does the use of local rice husk ash affect the counterfort retaining walls' properties in terms of: 4.1. Workability 4.2. Compressive Strength 4.3. Cost Efficiency	1. Survey questionnaire 2. Face to Face interview 3. Local RHA Testing 4. Statistical treatment of data 5. Design phase & Simulation 6. Cost analysis	1. N/A

Figure 2. *Conceptual Framework*

Statement of the Problem

In this study, the researchers aim to determine the data that are to be considered in the design of the counterfort retaining wall. It seeks to answer the following questions:

1. What is the demographic profile of the respondents in terms of:
    1.1. Age
    1.2. Length of Residency
2. How does the frequent landslide affect the citizens of Norzagaray Homes Phase 2, Brgy. Bitungol, Norzagaray, Bulacan in terms of:
    2.1. Transportation
    2.2. Perceive Safety
3. How does the counterfort retaining wall under various loading combinations perform structurally in terms of:
    3.1. Stability against Overturning
    3.2. Stability against Sliding
    3.3. Stability against Bearing Capacity Failure
4. How does the use of local rice husk ash affect the counterfort retaining walls' properties in terms of:
    4.1. Workability
    4.2. Compressive Strength
    4.3. Cost-Efficiency

Objectives of the Study

This research aims to design a sustainable retaining wall that can be implemented along the main road of Norzagaray Homes Phase 2. The objectives of this study include and limited to:

1. To know what is the demographic profile of the respondents in terms of:
    a. Age
    b. Length of Residency
2. To assess how does the frequent landslide affect the citizens of Norzagaray Homes Phase 2, Brgy. Bitungol, Norzagaray, Bulacan in terms of:
    a. Transportation
    b. Perceive Safety
3. To know how does the counterfort retaining wall under various loading combinations perform structurally in terms of:
    a. Stability against Overturning
    b. Stability against Sliding
    c. Stability against Bearing Capacity Failure
4. To identify how does the use of local rice husk ash affect the counterfort retaining walls' properties in terms of:
    a. Workability
    b. Compressive Strength
    c. Cost-Efficiency

Hypothesis

Ha. There is a significant effect on workability, compressive strength, upfront cost in utilizing local rice husk ash as sustainable material for counterfort retaining wall along main road of Norzagaray Homes Phase 2, Brgy. Bitungol, Norzagaray, Bulacan.

Ho. There is no significant effect on workability, compressive strength, upfront cost in utilizing local rice husk ash as sustainable material for counterfort retaining wall along main road of Norzagaray Homes Phase 2, Brgy. Bitungol, Norzagaray, Bulacan.

Significance of the Study

The result of the study, "Design of Counterfort Retaining Wall with Integration of Rice Husk Ash along Main Road of Norzagaray Homes Phase 2, Brgy. Bitungol, Norzagaray, Bulacan," will be beneficial to the following;

For Local Residents - It will raise awareness for local residents about innovative and sustainable materials used. The results of this study could ensure the safety of several people, houses, roads and other infrastructures.

For the School and Professor/Instructor - It can help the instructor to gain more knowledge and assist student on how to apply theoretical knowledge in engineering principles. This may also serve as an example in discussing topic related to the study.

For the Government - This research supports the government's goal towards its infrastructure budget and use of sustainable materials. This will also lead to the improved infrastructure and overall resilience of the city.

For Future Researchers - This study will serve as a reference for design of retaining wall to future researchers in their future studies. It can also be used as a possible related literature.

Scope and Limitation

This research focuses to design a hillside road retaining wall for the slope soil area affecting the housing residents along main road of Norzagaray Homes Phase 2, Brgy. Bitungol, Norzagaray, Bulacan. The study will primarily involve residents of the area as participant respondents. They will provide insights into existing conditions and challenges. The time frame of the study will span over the 5 months from the data collection to analysis and report preparation.

This study is limited to structural and cost analysis of the retaining wall design. It excludes the onsite techniques to be implemented in the construction, actual estimates of materials based on adjusted inflations, & advance engineering factors such as seepage, & long-term creep. The results were specific to the various design assumptions in Norzagaray Homes Phase 2, main road & material tested that was considered may not be applicable to all construction projects.

Definition of Terms

In order to achieve clarity and a better understanding of the study, the researchers defined the following words used in the study.

American Concrete Institute (ACI) - Leading global authority in America that create and optimize structural codes. It is where the National Structural Code of the Philippines is derived from.

Compressive Strength Test – Test that compute the compressive strength of cured concrete samples. It is tested with universal testing machine.

Counterfort Retaining Wall - It is the designed for retaining large quantities of soil, particularly in tall structures.

Life Cycle Cost Analysis (LCCA) - It refers to estimate the overall costs of project alternatives and to select the design that ensures the facility will provide the lowest overall cost of ownership consistent with its quality and function.

National Structural Code of the Philippines - It is the implemented code standards for construction in the Philippines.

Rankine's Earth Pressure Theory - It is simplification of computing the lateral earth pressure that the structure supports. A field solution that predicts active and passive earth pressure.

Retaining Wall (RW) - It refers to prevent the blockage of road due to landslide. In this study, the researcher uses retaining wall for safety of passerby, with the use of rice husk ash it can use to build the strong and durable retaining wall.

Rice Husk Ash (RHA) - It refers to the replacement, which contain a pozzolanic properties to form cementitious compounds. This will be used for reinforcement that are efficient to strengthen the structures.

Slump Test – A standard test for concrete to identify their workability and consistency.

Soil Bearing Capacity (SBC) - is the allowable maximum pressure that the soil can carry without failing or undergoing excessive settlement.

STAAD Pro - It is a highly competitive software that provides a user-friendly interface, facilitating civil structures' modeling and design.

Terzaghi's Effective Stress Theory - One of the most fundamental concepts in soil mechanics, it is the computation of the overall stress that the soil carries minus the force exerted by water.

CHAPTER 2

Review of Related Literature

This chapter presents a review of related literature and studies, following a thorough search done by local and foreign researchers. Those included in this chapter aid familiarizing with relevant and similar information to the current study.

Foreign Literature

A study by Pollock & Wartman (2020), present a human vulnerability curve that links an individual's probability of death to landslide inundation depth. Their study provides community-scale hazard awareness programs and training for citizen first responders offer a potent means to maximize survival rates in landslides. The authors adopt the term, using landslide mortality to refer not only to the rate of death in landslide incidents but also more generally to the contributing human factors and actions (Pollock & Wartman, 2020).

Shabbir et al. (2022) focus on mortality, gender deceased, main triggers and regional identification of the hotspots in Pakistan. A study on the effects of fatal landslides on the global scale also validates that the extreme rainfall is the major cause of landslides in more than half of the cases of landslides triggered by rainfall. There is a high correlation between the landslide and slope failures of the mountains or hills, and such landslides pose greater threats to the valleys as the vulnerability of mountain

slopes gets higher due to weathering, deforestation, and other human-induced activities (Shabbir et al., 2022).

According to Putra et al. (2025), the construction of retaining walls is essential due to hilly topography and the increasing risk of slope instability caused by high rainfall and lateral soil pressures. The study focuses on determining the dimensions, costs, and construction timelines of cantilever and gravity retaining walls along the Temuireng-Jetis road section, a strategic route affected by frequent landslides. Their findings contribute to efficient and sustainable infrastructure development, offering practical solutions for areas with varying topographic challenges and soil conditions (Putra et al., 2025)

A foreign study by Kamal et al. (2023), used an interdisciplinary and innovative approach to analyze the slope stability of landslides, evaluate the effectiveness of existing structural mitigation measures, and assess the risk perception of those living in danger zones. Therefore, a structured and systematic social questionnaire survey was conducted to understand the community response to landslide mitigation measures and their perception. The Survey results revealed that at least 70% of respondents believed that concrete retaining walls are more effective in reducing landslide occurrence compared to other measures (Kamal et al., 2023).

A study by Balasbaneh et al. (2020) where they incorporate the use of Life Cycle Cost Analysis methodology in assessing the suitable and economical earth retaining wall to use. They found out that gabion wall had the highest overall sustainability performance among wall types. LCCA methodology is important to

assess the different types of retaining wall to be designed for Norzagaray Homes Phase 2.

Local Literature

Recent landslides in the Philippines have caused many fatalities, loss of livelihoods; destroyed infrastructures, damaged natural resources and displaced several communities. A 2025 study by Ollet developed a theory model on community resilience called the Landslip-Disaster Quadrant Model to examine the capacity for resilience and the vulnerability of threatened communities. Sustaining healthy and resilient communities and protecting the ecosystem from natural disasters is a key development goal (Ollet, 2025).

Jahan (2023) discuss the causes and effects of landslide. Landslides can cause significant loss of life and property, it can bury houses, roads, and other infrastructure, causing fatalities and injuries. By taking proactive measures, we can reduce the risk of landslides and their devastating effects on society (Jahan, 2023).

A local study by Santos (2025) assess that the properties built on sloped land face unique structural challenges, which are especially heightened during the rainy season. They found out that without protective structures in place, parts of the land can give way, putting the entire property and its residents at serious risk. The study recommends installing a retaining wall is a practical measure that safeguards both your investment and your safety (Santos, 2025).

In their study, Pangilinan et al. (2025) shows that retaining walls are recognized as an effective engineering solution for stabilizing slopes and preventing landslides. The study is all about the enhancement of the safety and well-being of the community against any potential issues caused by the instability of the slope in the locality. The analyses demonstrated that the design satisfied the safety conditions by achieving a factor of safety exceeding the required minimum for both internal and external stability (Pangilinan et al., 2025).

Salonga et al. (2023) research study required a data from previous retaining walls to be used as a reference in designing the gabion retaining wall. They used trial-and-error method to calculate the probable design for the gabion retaining wall to achieve an effective result for the design criteria specified by the American Society of Civil Engineers (ASCE). The researchers concluded that this design of gabions retaining wall could be used as a future reference and is acceptable if it was ever installed as an alternative to sheet piles (Salonga et al., 2023).

Foreign Study

Gravity retaining wall offers a simple solution due to simplicity construction in which the Civil Engineers agree upon. According to Bari et al. (2021) study "Optimum height of the Retaining Gravity Wall" gravity retaining wall revolves around the reliability of its mass as the supporting factor in stabilizing the structure against the lateral earth pressure. Also, according to Bari et al. (2022, October) recent

study: “Optimal Cost of Slope Stabilization with Retaining Wall” gravity retaining wall is not optimized for high range type of wall stating its limits to 1–7-meter range. This impacts the perception of Engineers as adapting gravity retaining wall when assessing it as a sustainable solution for hillside of Norzagaray Homes, Phase 2. It also takes a lot of space in order to design a safe and stabilized retaining wall. Gravity wall’s safety and cost-effectiveness, with lower heights are much favorable for environmental sustainability.

On the other hand, the cantilever retaining wall heavily relies on the weight of the backfill soil so it is stabilized. According to Putra et al. (2025) cantilever reinforced retaining wall is generally preferred in moderate height ranging from 6-8 meters. It is material-efficient than gravity wall because it utilizes reinforcement strength in helping in the shear and bending moment produced by soil. Additional consideration when designing cantilever retaining wall involves the careful proportioning of the stem, base, and heel with stability check internal & external. Since the cantilever retaining wall uses reinforcement the usage in greater heights 7 meters above is considered uneconomical due to higher cost of reinforcement requirement.

Counterfort retaining wall was deemed as the best retaining wall type to use in Norzagaray Homes Phase 2 according to preferences of Civil Engineers. Basically, counterfort retaining wall is the enhanced version of cantilever retaining wall. The difference is it now incorporates the use of transverse support (Counterfort) allowing for design of thinner wall sections. Counterfort supports improved stability and reduces material stress strain. Counterfort retaining wall easily is the best in higher

height of structure in which gravity retaining wall and cantilever retaining wall are at disadvantage. Comparative studies show that counterfort walls are more economical and stable for large heights, especially when optimized with relief shelves or advanced design methods. (Yang et al., 2023)

According to Hasan et al. (2022), their research is to determine the influence of different rice husk ash (RHA) concentrations on the fresh and mechanical properties of high-strength concrete. RHA was employed to partially replace the cement at 5%, 10%, 15%, and 20% by weight. Moreover, incorporating 10% of RHA provides the highest compressive strength, splitting tensile, and flexural strength, with an improved initial surface absorption and microstructural evaluation and greater eco-strength efficiencies. Thus, the current findings demonstrated that RHA can be used in the concrete industry as a possible revenue source for developing sustainable concrete with high performance (Hasan et al., 2022).

In a study by Endale et al. (2022), they conducted an extensive literature review about the rice husk ash as a replacement of cement. Their study found that the rice husk ash has the potential to replace by up to 10% to 20% of cement total weight without compromising the concrete performance due to its high pozzolanic properties. Rice husk ash performs well in terms of fresh properties (workability, consistency and setting time). Due to involvement of amorphous silica reactions, the mechanical properties (compressive, tensile and flexural strength) of RHA containing concrete increases up to a certain optimum level. This study has the impact for the

environmental sustainability to contribute for the economy in the construction industry (Endale et al., 2022).

Local Study

A similar study with Pangilinan et al. (2025, May) entitled: “A Proposed Design of Retaining Wall as a Countermeasure Against Landslide in Villa Maria, Porac, Pampanga” was also a beneficial guide for our research. As they’ve used a purposive sampling method technique in which they survey Engineers in DPWH Pampanga 2nd DEO which has experience in geotechnical work. In their study, they have four choices design selection of gravity, cantilever, counterfort, crib. Their study evaluates the structure's performance in effectiveness, resiliency, and life expectancy in classifying the suitable retaining wall to assess how these structures perform under different conditions.

Pangilinan et al. (2025, May) study found that in terms of effectiveness the cantilever retaining wall received the highest mean score of 3.29, based on Civil Engineers response. This indicates that it is effective among the choices retaining wall because it excels in stabilizing soil, preventing erosion, and maintaining structural integrity, making it a reliable choice for engineers. Also, in terms of resiliency Engineers still prefer cantilever achieving a mean score of 3.29. This perceived as having superior resiliency compared to other types of retaining walls. According to the data presented in their study, which outlines the life expectancy of four distinct types

of retaining walls, the cantilever wall received the highest mean score of 3.10. This indicates that civil engineers consider the cantilever wall the most suitable for long-term durability. Compared to the other types, it is believed to have a greater life expectancy, making it a preferred choice for projects requiring reliable, long-lasting performance in the face of environmental challenges. Their study about overall retaining wall performance yields with mean result of: 3.03, 3.23, 3.16, and 2.74 for gravity, cantilever, counterfort, and crib, respectively. Their study suggests the best retaining wall to adapt is cantilever and counterfort.

In the study of Cruz et al. (2025), they discussed about the design of cantilever retaining wall with NSCP 2015 provisions in the design of retaining wall. Aforementioned were the key parametric used to identify if the structure is stable: factor of safety against overturning, sliding, soil bearing capacity. Manual calculation by parts of retaining wall were used to design. It is then verified with STAAD Pro (Cruz et al., 2025).

A study about the compressive strength of concrete with rice husk ash as cement replacement. Suggest that a 10% replacement of cement total weight with rice husk ash improved compressive strength (Cabahug, 2023). This further supports the use of RHA as a supplementary cementitious material in the design of the counterfort retaining wall. Where you can integrate RHA as a sustainable solution to lessen biowaste products produced by farmers.

A local study of Jr et al. (2023), focused on provided information that concrete produced by utilizing cement replacements such as RHA can produce better

compressive strength when chemical admixtures are considered, which can be applied to general reinforced cement concrete. Moreover, the result revealed that the optimum increase of compressive strength of 9.8% against the control concrete mix was achieved when a concrete mix of 10% RHA partial cement replacement was added with 1.5% of admixture. The researcher recommended that a study to derive a cost-benefit analysis of using admixtures in concrete with RHA partial cement replacement be conducted to determine the economic value of this concrete alternative (Jr et al., 2023).

Synthesis of Review of Related Literature and Study

Both Foreign Literature and Local Literature emphasize that retaining walls whether gravity, cantilever, or counterfort types play a crucial role in enhancing safety and infrastructure resilience in landslide-prone areas. Taken together, all mentioned research studies point out two significant directions relevant to our study. Counterfort retaining wall is structurally advantageous and cost-efficient for higher walls in comparison with gravity retaining wall and cantilever retaining wall. Using Rice Husk Ash is a sustainable approach with the enhancement of mechanical material properties suitable for integration into reinforced concrete. The research established on these findings by designing a counterfort retaining wall with integration of RHA tailored to the site conditions of Norzagaray Homes Phase 2. This addresses both structural safety and sustainability, filling a local gap problem that occurs in the vicinity of the surrounding homes.

CHAPTER 3

Research Methodology

This chapter outlines the research methodology employed by the researcher to answer systematically the study of quantitative through experimental and descriptive research. It details the research design, sample and population, research instruments, data gathering, and statistical tools used to ensure the accuracy and reliability of the results. The methodology aims to provide a clear and systematic approach to data-gathering procedures and the interpretation of data and its adequacy.

Research Design

The study will use experimental quantitative research design. The researcher will conduct investigation if there is significant difference with experimental concrete with RHA and controlled normal concrete. The key parametric to be measure are: workability, & compressive strength. Later on, the compressive strength will be used for analysis and design of counterfort retaining wall in STAAD Pro.

Also, a descriptive quantitative research design. This will help to examine and analyze the perceptions of motorists and residents who frequently travel along the main road of Norzagaray Homes Phase 2, regarding how the frequent landslide poses a significant threat to their safety and security.

Sample and Population

The target population for this study will be the motorists and residents of Norzagaray Homes Phase 2, Brgy. Bitungol, Norzagaray, Bulacan, specifically those in the age range of 18-60 that frequently travel along the main road. A simple random sampling technique will be used to select respondents, ensuring that every motorist, and resident has an equal chance of being included in the study. The total sample size will be 140 respondents, which is considered through Slovin's formula based on the population size of the area. This sample size will help guarantee that the results are statistically significant and representative of the community's view.

Research Instrument

In this study, the following instruments are utilized by the researcher to gather all the data needed to answer the specific problems in the study.

Design and Detailing

The AutoCAD and RCDC software will be used to achieve accuracy and efficiency during the structural design and detailing process of a counterfort retaining wall. RCDC was used to design reinforced concrete elements using NSCP 2015 and ACI 318 2011 provisions. RCDC design output was then imported into AutoCAD to allow for exact construction drawings and comprehensive reinforcement schedules.

AutoCAD and RCDC will assist researchers in simplifying the detailing process, increasing productivity and reducing errors in the design documentation process.

Testing via Software

The researchers manually calculate the loads acting on retaining wall structure then it will be analyzed and design with STAAD Pro. STAAD Pro uses NSCP 2015 and ACI 318 2011 provisions in analyzing and designing of structure. This software provides a relatively user-friendly that helps users draw the structure and enter loads intensity. STAAD Pro provides us with a platform for analyzing and designing complex structures such as counterfort retaining wall with ease and code compliant.

RHA Testing

A cylindrical specimen that will undergo various tests has an inclusion of rice husk ash. It involves a Universal Testing Machine (UTM) that will determine a concrete's compressive strength by applying a progressively increasing axial load to a cylindrical specimen until it fails. Also, by conducting a compressive strength test UTM will be able to determine the concrete strength to be use in design and analysis of retaining wall. The researchers will also conduct a slump test to measure if there are changes in the workability and consistency of experimental concrete against controlled concrete (with RHA).

Cost Estimation

Excel spreadsheets were created to list materials, labor, and equipment costs, allowing easy calculation and adjustment of the total budget of a project. This study will utilize excel sheets to calculate conceptual estimates for the design project. It helps the researchers to have organized data clearly about the cost estimation process.

Data Gathering

The process will begin with an introductory session explaining the purpose of the research study and ensuring that participants understand their rights and voluntary anonymous participation. The data will be collected within the area using face-to-face surveys for motorist and residents. The survey will take approximately 10-20 minutes to complete per respondent. The data collection will take place over a period of two weeks, ensuring adequate time to gather sufficient responses.

The obtained results from the data collection were tabulated, & analyzed using independent t-test to determine if there is significant difference in data. The researcher also use weighted mean. This will help in findings for conclusion and interpretation of data.

Statistical Treatment

This study will utilize independent t-test as the primary statistical method to analyze the data generated. Independent T-test is a statistical test used to compare the means between controlled group & experimental group. This test indicates if there is significant difference between means of the two selected samples. The researcher also use weighted mean to summarize the interpretation of the respondents.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

Equation 1 *Independent t-test*

Where:

$\bar{x}_1$ = Mean of group 1

$\bar{x}_2$ = Mean of group 2

S_1^2 = Variance of Group 1

S_2^2 = Variance of Group 2

n_1 = Sample size of group 1

n_2 = Sample size of group 2

$$M = \frac{\sum(F \times w)}{\sum F}$$

Equation 2 *Weighted Mean*

Where:

F = Number of respondents

w = Weight equivalent

$$n = \frac{N}{(1 + Ne^2)}$$

Equation 3 *Slovin's Formula*

Where:

n = Sample size

N = Population size

e = Margin of error

$$K_a = \frac{1 - \sin\phi}{1 + \sin\phi} \ \ (Assuming\ \beta = 0)$$

Equation 4 *Rankine Active Earth Pressure Coefficient*

Where:

ϕ = Internal Angle of Friction

K_a = Rankine Active Earth Pressure Coefficient

$$FS_{OM} = \frac{M_r}{M_o}$$

Equation 5 *Factor of Safety against Overturning*

Where:

FS_{OM} = Factor of Safety against Overturning Moment

M_r = Righting Moment ($\frac{Kn}{m}$)

M_o = Overturning Moment ($\frac{Kn}{m}$)

$$FS_S = \frac{R}{P_a}$$

Equation 6 *Factor of Safety against Sliding*

Where:

FS_S = Factor of Safety against Sliding

R = Resisting Force (Kn)

P_a = Sliding Force ((Kn)

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Kaypian Road, Corner Quirino Highway
San Jose del Monte, Bulacan 3023

October 18, 2025

HON. BALTAZAR ESPIRITU
Barangay Chairman
Barangay Bitungol
Norzagaray, Bulacan 3013

Subject: Request for Permission to Conduct Research

Dear Hon. Espiritu,

Greetings in peace!

In partial fulfillment of our requirements for our degree, we, fourth-year civil engineering students from La Concepcion College, would like to ask for permission to conduct our research study entitled:

"Design of Counterfort Retaining Wall with Integration of Rice Husk Ash along Main Road of Norzagaray Homes Phase 2, Brgy. Bitungol, Norzagaray, Bulacan."

In line with this, we would like to respectfully request permission to conduct research and a survey within your barangay. We assure you that all information gathered will be kept strictly confidential and used solely for academic purposes. We are hoping for your kind approval on this matter.

Thank you for your time, support, and consideration.

Respectfully yours,
Kyle Abijah R. Baguan
Hazel Mae S. Borra
Diana Mea B. Padel
Romulo B. Ramirez
Researchers
La Concepcion College

OFFICE OF THE BRGY. SECRETARY
RECEIVED
SEC. PRINCESS F. VELARDE
10/20/25 TIME: 10:12 AM

Noted By:

Engr. Eloisa P. Cadag, Reg. CE., MACT
Research Adviser

10/21/25
Engr. Jore Gil D. Galeza, Ph.D., MEM, SO2
Division Head of Civil Engineering

TITLE: “DESIGN OF COUNTERFORT RETAINING WALL WITH INTEGRATION OF RICE HUSK ASH ALONG MAIN ROAD OF NORZAGARAY HOMES PHASE 2, BRGY. BITUNGOL, NORZAGARAY, BULACAN

GENERAL INSTRUCTIONS:

Purpose: This survey aims to gather information from residents and motorists about their experiences and concerns in living and traveling in their areas that are prone to landslides. The responses will help us in planning safer infrastructure that will prevent future landslides.

Confidentiality: All information you provide will be treated with **strict confidentiality**. Your answers will be used only for academic and research purposes. Participation in this survey is **voluntary**, and you may skip any question that makes you feel uncomfortable.

Resident Survey:

I. PROFILE

Instructions: Put a check (✓) inside the box corresponding to your chosen answer. You may leave your name blank if you prefer to remain anonymous. Leaving your name blank will not affect the validity of your responses.

1.1. Demographic Information

1. Name (Optional): _____
2. Age:
   - ☐ 18-25
   - ☐ 26-40
   - ☐ 41-60
3. How long have you lived/passed in this area?
   - ☐ Less than 1 year
   - ☐ 1-5 years
   - ☐ More than 5 years

II. SURVEY QUESTIONNAIRE

Instructions: Please read each question carefully and choose only one (1) answer that best represent your responses. Put a check (✓) inside the box corresponding to your chosen answer.

SCALE:
- 5 – Strongly Agree (SA)
- 4 – Agree (A)
- 3 – Neutral (N)
- 2 – Disagree (D)
- 1 – Strongly Disagree (SD)

2.1. Transportation

Statement	(Strongly Disagree)	(Disagree)	(Neutral)	(Agree)	(Strongly Agree)
1. The transportation routes are affected when landslides occur in our community.	☐	☐	☐	☐	☐
2. Landslides causes difficulties for people passing through the affected area.	☐	☐	☐	☐	☐
3. Road blockages due to landslide significantly disrupt our daily lives.	☐	☐	☐	☐	☐
4. The landslide previously affected our access to work, school, or health services.	☐	☐	☐	☐	☐

2.2. Perceive Safety

Statement	(Strongly Disagree)	(Disagree)	(Neutral)	(Agree)	(Strongly Agree)
1. Landslides are a serious threat to my personal/family safety in our area.	☐	☐	☐	☐	☐
2. I feel confident that our location is safe from landslides.	☐	☐	☐	☐	☐
3. I believe the hillside or slope near our home is stable.	☐	☐	☐	☐	☐
4. I am concerned that landslides could damage our vehicle or property.	☐	☐	☐	☐	☐

La Concepcion College
Kaypian Road, Quirino Highway, SJDM, Bulacan, Philippines
Website: https://laconcepcioncollege.com
Telefax No. (044) 762-36-60

CERTIFICATE OF VALIDATION

This is to certify that the researchers have successfully completed the validation process for the research questionnaire of the study entitled "**Design of Counterfort Retaining Wall with Integration of Rice Husk Ash along Main Road of Norzagaray Homes Phase 2, Brgy. Bitungol, Norzagaray, Bulacan.**"

The validation of the questionnaire was conducted by a professional, who has thoroughly examined and assessed its content and appropriateness for the research objectives. The validation process confirmed that the questionnaire meets the necessary criteria for collecting accurate and valuable perceptions for our study.

This certification is granted to acknowledge the dedication and expertise demonstrated by the professional in ensuring the reliability and validity of the study.

Rissa N. Alovera, Ph.D.
San Martin National High School - Master Teacher I
Date: 15 OCTOBER 2025

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The validation of the research was conducted by our appointed Structural Engineer, who has thoroughly examined and assessed its structure, content and appropriateness for the research objectives. The validation process confirmed that the research for structural design meets the necessary criteria for collecting accurate and valuable design for our study.

This certification is granted to acknowledge the dedication and expertise demonstrated by the Structural Engineer in ensuring the reliability and validity of the study.

Engr. Diomedes D. Matias, MSCE
Structural Engineer
Date: 22 OCTOBER 2025

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This certification is granted to acknowledge the dedication and expertise demonstrated by the professional in ensuring the reliability and validity of the study.

Jore Gil D. Galeza, Ph.D., MEM, SO2
La Concepcion College – Division Head of Civil Engineering
Date: 27 OCTOBER 2025